ELEC 480: Introduction to Neuroengineering

Measuring and Manipulating Neural Activity

Fall 2015

Crosslisted as: ELEC 580, BIOE 480, BIOE 590

Instructor:

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Course Grader:
TBA

Class Hours: Tuesday, Thursday 2:30-3:45 Duncan Hall 1070
Fall Semester, 2015

Course website: The primary location for course information, assignments, and other resources is the course website. One particular feature is the forum - if you have specific questions about course content or assignments, please post them on the forum. As a corollary, you may find it useful to check the forums for answers as questions arise.
https://owlspace-ccm.rice.edu/portal/site/BIOE-480-BIOE-590-ELEC-480-ELEC-580-001-F15

Course Description: Neuroengineering is an emerging discipline focused on measuring and manipulating the activity of the brain and nervous system. Using the language of physics and engineering, this course serves as an introduction to neuroengineering for students who may have little or no prior biology training. The course begins by describing how ion channels, membrane potentials, action potentials, and synapses represent information within the brain. Students will then learn a variety of techniques to model this behavior, and modern methods to measure and manipulate neural activity using electrical, optical, and genetic techniques. Students will be expected to be familiar with voltage, current, resistance, capacitance, simple circuits, and statistical mechanics. Homework assignments will require the use of Matlab.

Objective: Students should learn the fundamentals of how the activity of neurons represents information within in the brain and how this activity can be experimentally monitored and manipulated.

Outcome: Students completing the course should be able to:

1. Explain the biophysical basis of neural activity
2. Describe the methods used to record and manipulate neural activity
3. Mathematically model the electrophysiological behavior of neurons
4. Prepare an evaluate scientific proposals based on neural interface technology

Prerequisites: Basic circuits (ELEC 242 or equivalent), Physics of Electricity (Phys 112, 125, or equivalent), Matlab will be used for many of the homework assignments so some familiarity with it will be useful.

Textbook: *Molecular and Cellular Physiology of Neurons* by Gordon Fain (Recommended)

Grading: Grades will be based on: approximately four homework assignments (30% total), one midterm (30%), and one final project (40%).

You can be one day (24 hours) late on one HW assignment without any penalties. Otherwise a 50% penalty will be assessed on late HW assignments. Assignments received after solutions are posted will not be graded.

Technology Policy: Laptops and cell phones may be used during class for note taking and activities directly related to the course. All other use of laptops and cell phones is not permitted to avoid distracting fellow students.

Honor code: You are encouraged to work *with* other students in ELEC 480 on homework problems. Each student, however, must turn in his or her own copy of the solutions. You should avoid using the completed work of other students, old homework solutions, and old exams and solutions. Exams must be completed independently; for take-home exams, rules regarding the use of outside resources will be specified in the exam materials.

500 Level Additional Assignments: Students enrolled in the 500 level course will have two additional assignments: a written literature review and generating example homework problems.

Course Outline:

1. **What is Neural Activity:**
   - 1.1 – The brain, neurons, and glia
   - 1.2 – Ion channels, membrane potentials, and action potentials
   - 1.3 – Modeling neural activity
   - 1.4 – Active and passive electrical propagation in neurons
   - 1.5 – Electrical and chemical synapses

2. **Electrical recording and stimulation technology:**
   - 2.1 – Patch clamp electrophysiology
   - 2.2 – Local field potentials and single unit recording

3. **Macroscale recording technology:**
   - 3.1 – fMRI, EEG, ECOG

4. **Optical stimulation technology:**
   - 4.1 - Optical recording techniques: voltage and calcium sensitive imaging
   - 4.2 - Genetic engineering in the brain and genetically encoded Ca^{++} indicators
   - 4.3 - Optical stimulation and inhibition: Photolysis and Opotogenetics
   - 4.4 - Light scattering in biological tissue
   - 4.5 - Multiphoton microscopy and other advanced microscopy technology

5. **Neural Adaptation:**
   - 5.1 – Synaptic and homeostatic plasticity
   - 5.2 – Learning and Memory

6. **Final Project – Scientific Research Proposal:**

   The goal of the final project is to familiarize you with open-ended problem solving, scientific grant writing, and peer review.

   In teams of two you will craft a proposal for new neurotechnology or to use existing neurotechnology to solve a research problem. You will receive a call for proposals and work with your team to prepare a 1 pg summary of your idea followed by a full proposal for peer-review from your own classmates.

Each team will be given 10 minutes to present their proposal to the class. The final grade for this project will be based on your call, proposal, presentation, and peer review.

6.1 – Prepare 1pg summary “white paper” of your idea
6.2 – Based on instructor feedback develop the white paper into a full 4 pg proposal
6.3 – Present your research proposal to the class
6.4 – Peer review proposals

Absence Policies: Class attendance is required during the proposal presentations at the end of the semester. Students are not required to attend instructor lectures, however students will be responsible for the material covered during these lecture and some of the material will likely be outside of the textbook. The slides presented during class will be available on the course website, and it is the responsibility of the student who missed class to work with other students to review any material that is not represented in the online documents.

Students with Disabilities: Any student with a documented disability seeking academic adjustments or accommodations is requested to speak with one of the course instructors during the first two weeks of class. All discussions will remain as confidential as possible. Students with disabilities will need to contact Disability Support Services in the Allen Center.

Information contained in this syllabus, other than the absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.